NASA CASE NO. GSC-13112-1

PRINT FIG. The Figure

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(NASA-Case-GSC-13112-1) SURFACE TENSION CONTAINED LIQUID CRYOGEN COOLER (STCLCC) Patent Application (NASA) 5 p CSCL 13B

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AWARDS DIGEST

NASA Case No. GSC 13,112-1

SURFACE TENSION CONFINED LIQUID CRYOGEN COOLER (STCLCC)

This invention relates generally to coolers having containers or dewars for cryogens and more particularly to containers for liquid cryogen coolers useful in applications involving the cooling of instrumentation in outer space environments. The ultimate objective of this invention is to provide a cryogenic cooler for use in craft such as launch, orbital and space vehicles that are subject to substantial vibration and weightlessness wherein instrumentation external to the cooler will be maintained at precise very low temperatures (10-140°K).

The Figure illustrates a cryogenic cooler which is representative of the invention. The cooler is shown generally at 10 which comprises a cylindrical inner tank 12 which is insulated 26 and surrounded by an evacuated shell 22. A porous open celled ceramic sponge-like material 36 extends throughout interior space 20 of inner tank 12. Tank 12 is filled with liquid cryogen 34 via fill tube 44. Ceramic sponge 36 is a high surface area, low density open cell material and is capable of acquiring and holding in place liquid cryogen 34 because of the high surface tension of the cryogen with respect to the sponge 36. A cooling finger 32 extends into the liquid cryogen 34 stored in inner tank 12 and extends externally to instrumentation that is to be cooled located outside of cooler 10. Heat is transferred from the instrumentation into cooling finger 32 and subsequently into the liquid cryogen 34. Any cryogen gas that is formed within tank 12 due to the heat transferred from the instrumentation into liquid cryogen 34 is vented and expelled from tank 12 via vent tube 38. This enables the instrumentation to be maintained at a precise temperature level because the cryogen is maintained in its liquid state.

Novelty is believed in the provision of a liquid cryogen cooler for spacecraft that will provide precision cooling to instrumentation located external to the cooler in zero-gravity environments.

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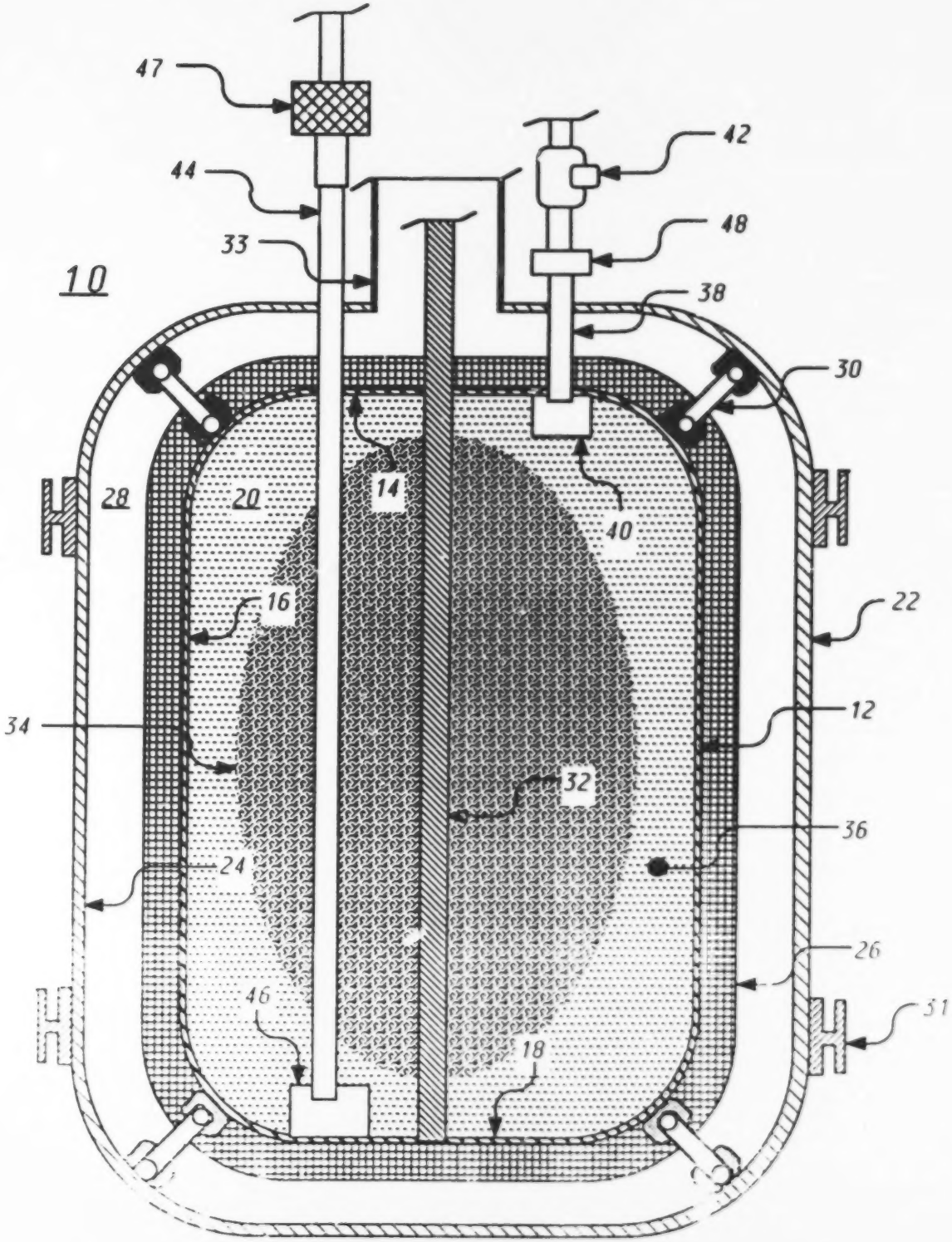
Filed 6-13-88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NASA Case No. GSC 13,112-1 PATENT

SURFACE TENSION CONFINED LIQUID CRYOGEN COOLER

Origin of the Invention

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of the royalties thereon or therefor.

Field of the Invention

The present invention relates generally to coolers having containers or dewars for cryogens and more particularly to containers for cryogenic liquid coolers useful in applications involving the cooling of instrumention in space.

Background of the Invention

The requirements of satellite and space probe borne super cooled instrumentation for cryogenic cooling fluids necessitate provision for containing the necessary cryogen supply during launch and for periods up to a year or more, thereafter. An example of such an instrument is an infrared sensor which requires cryogenic liquid cooling to obtain optimum infrared radiation sensitivity. Such on-orbit instrumentation must be maintained at temperatures of typically 10-140°K. The use of cryogens avoids the power usage and complexity of a powered cooling system.

Prior art orbital cryogenic systems required maintenance of the cryogen in the frozen state. If the cryogen is allowed to liquify, the vent port of the cooler can become blocked with liquid, resulting in the liquid being immediately pumped out to space, depleting of cryogen and introducing safety hazards at the vent exhaust. This condition can readily occur due to vibration during launch and weightlessness during orbit. Freezing of the cryogen requires cooling coils, coolant supply, and regulation equipment and instrumentation to assure operators that the cryogen is maintained in a frozen state, adding weight and complexity to the spacecraft. Since the frozen cryogen must be kept at a vapor pressure below its triple point, generally below one atmosphere of pressure, a pumping system must be incorporated if the solid cryogen

is to be maintained on the launch pad beyond the limited amount of time before heat leak of the system results in cryogen melting. These pumping systems are heavy, require power, add complexity to the system design and operation, decrease system reliability, and create safety problems. Without such pumping systems, the launch vehicle carrying the cryogenic device can remain on the launch pad for only a limited amount of time without servicing of the frozen cryogen dewar. Procedures to freeze and subcool the cryogen also add complexity and time to launch pad operations, which are normally time and safety critical. Another drawback of the frozen cryogen system is that its cryogen cannot be replenished in orbit or in space by service vehicles, a requirement if sensors are to remain useful beyond a relatively short time in space. The above-mentioned disadvantages and limitations of the prior art frozen cryogenic system could be overcome if a practical liquid cryogen system could be provided.

Summary of the Invention

It is therefore an object of the present invention to provide an improved cryogenic cooling system for cooling space based super cooled instruments wherein the requirement for maintaining the cryogen in the frozen state is eliminated.

It is another object of the invention to provide an improved cryogenic dewar system capable of operating with a liquid cryogen supply while avoiding the chance of uncontrolled loss of liquid through the vent under launch and orbital conditions.

It is a still further object of the invention to provide an improved cryogenic cooling system which can remain on the launch pad for extended periods of time without provision for cooling coils and pumping systems, or cooler servicing.

The foregoing and other objects are accomplished by providing a cooler, according to the present invention, containing a high surface area, low density open cell material such as ceramic or carbon "sponge" substantially throughout the contained volume therein. When the dewar according to the present invention is filled with cryogenic fluid, the cryogenic is acquired by the sponge material and held in place due to

the surface tension properties of the cryogen. This technique has been used in cryogenically frozen biomedical specimen shipping containers for terrestrial use; however, these shipping containers do not use zero gravity effects to favorably orient the cryogen, they do not directly use the cooling power of the liquid phase of the cryogen for precise temperature control, and they do not use a cold finger to allow cooling of remote instrumentation which is not actually situated with the dewar. All of these capabilities are original and critical to the operation of this invention. In the present invention, the liquid cryogen is kept away from the vent while the dewar is undergoing launch or zero-gravity operations and is forced to make good thermal contact with an internal cold finger inside the dewar. The "sponge" filled dewar according to the present invention overcomes the above-mentioned disadvantages of the prior art system in an inherently simple, reliable, and inexpensive device which will result in reduced costs, enhanced reliability and safety, and fewer ground servicing requirements for the launch vehicle. The inventive cooler system will provide serviceability on-orbit, which will be a wholly new capability for space borne cryogenic systems. This serviceability is extremely important to planned long duration on-orbit facilities. On the launch pad, the liquid cooler system can be replenished, a capability that is advantageous where long pre-launch delays are common, such as for the manned space shuttle.

Brief Description of the Drawing

The specific nature of the invention, as well as other objects, aspects, uses and advantages thereof, will clearly appear from the following description and from the accompanying drawing, in which:

The Figure is a cross-sectional view in elevation illustrating the liquid containing cryogenic cooler according to the present invention.

Description of the Preferred Embodiment

Referring now to the figure, which illustrates a surface tension contained liquid cryogen cooler 10 according to this invention. Cooler 10 is formed by a generally cylindrical inner tank 12 having upper wall

14, sidewall, 16, and lower wall 18 defining an interior space 20. Outer vacuum shell 22 is located exterior to and generally conformal to inner tank 12 and is made up of outer wall 24 and contains insulation layer 26. Insulation layer 26 is located in intimate contact with inner tank 12 and is spaced inward from outer wall 24 to form vacuum void 28. Inner tank 12 is secured within vacuum shell 22 by means of a low thermal conductivity inner tank support system 30, shown here as a strap, but which may also be struts, truss, or beam. Mounting rings 31 attached to the outer vacuum shell 22 allow the cooler 10 to be attached to the spacecraft containing the instrumentation to be cooled.

Cold finger 32 is mounted along the center axis of inner tank 12. Cold finger 32 is generally cylindrical in shape and extends from outside cooler 10 through inner tank 12 into and along the axis of cylindrical vacuum sleeve jacket 33. Cold finger 32 is effective to transfer heat from exterior sources, such as instrument detectors, along its length to the liquid cryogen 34 contained within the porous sponge 36. The liquid cryogen 34 is shown surrounding the cold finger 32 in a typical zero-g orientation.

Sponge 36 is located and extends substantially throughout interior space 20 of inner tank 12 and is effective to maintain the contained liquid cryogen in a fixed position relative to the cooler 10 through the liquid's surface tension properties.

Vent tube 38 is generally cylindrical and extends in fluid communication with vent void space 40 in sponge 36 located within the upper portion of interior space 20 through upper wall 14 of inner tank 12 and through outer vacuum shell 22 to the atmosphere and is effective to vent vaporized cryogen from cooler 10. A pressure regulator 42 is positioned within vent tube 38 to maintain system pressure at a desired level to maintain the cryogen in the liquid state, i.e., above its triple point, when vented to open space. Pressure regulator 42 may be an absolute type for maintaining a precise operating temperature, or a check valve, where variation in operating temperature is acceptable. Fill tube 44 is generally cylindrical and extends in fluid communication with fill flow relief space 46 through upper wall 14 of inner tank 12 and through outer vacuum shell 22 to allow filling inner tank 12 of

cooler 10 with cryogenic fluid. A cryogenic fluid coupler 47 is included to allow repeated servicing of cooler 10.

In operation, heat is transferred from a satellite mounted sensor through cold finger 32 to the liquid cryogen maintained within cooler 10. Vaporized cryogen resulting from this heat transfer is vented through vent tube 38 to the atmosphere.

Sponge 36 is a high surface area, low density open cell material which is preferably rigid and is capable of acquiring and holding in place liquid cryogen, due to the high surface tension of the cryogen with the sponge. A preferable sponge material is a micropore ceramic, composed of silicon, with free volume of 95% or greater, such as that designated as H.T.P.-6, which is available from Lockheed Missile and Space Company, Sunnyvale, CA. This material is more widely known for its use as thermal protection tile on the space shuttle. While the ceramic sponge material is remarkably durable, it is composed of brittle microscopic fibers which could be a source of particulate contaminates in the vent gas. A variety of steps can be taken to avoid vent gas contamination. That shown is a conventional filter 48 on the vent line 38 upstream of pressure regulator 42.

Tank 12, shell 22 and other structural features can be made of suitable metal, glass, composite or ceramic materials as is known in the art. In the embodiment shown, inner tank 16 and vacuum shell 24 is made of aluminum, support system 30 is a series of fiberglass support straps, and cold finger 32 is copper. Insulation layer 26 can be of any desired insulating material and may be disposed in single or multiple layers. Outer vacuum shell 22 is so disposed and configured within cooler 10 as to maintain a vacuum and thus further minimize heat load on inner tank 12 from the environment.

It will be understood by those skilled in the art that the embodiment shown and described is only exemplary and that various modifications can be made in the practice of the invention within the scope of the appended claims.

SURFACE TENSION CONFINED LIQUID CRYOGEN COOLER

ABSTRACT

A cryogenic cooler is provided for use in craft such as launch, orbital and space vehicles subject to substantial vibration, changes in orientation and weightlessness. The cooler contains a small pore, large free volume, low density material to restrain a cryogen through surface tension effects during launch and zero-g operations and maintains instrumentation within the temperature range of 10-140°K. The cooler operation is completely passive, with no inherent vibration or power requirements.